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Comparison of patient (POEM), observer (EASI, SASSAD, TIS) and corneometry measures of emollient effectiveness in children with eczema: findings from the COMET feasibility Trial

Running title

Comparison of eczema severity measures

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What is already known about this topic?

- There are many different patient and observer-reported measures of eczema severity with different levels of evidence for the measurement properties for each instrument. The value of "objective" measures of skin hydration is also unclear.
- POEM and EASI have been recommended by the Harmonising Outcome Measures for Eczema (HOME) initiative as core outcomes for all clinical eczema trials but they have not been widely used in community settings/populations with mild eczema.

What does this study add?

- In children with mostly mild-moderate eczema randomised to one of four emollients for 12 weeks, POEM, EASI, SASSAD and TIS all showed a reduction in eczema severity but skin hydration (corneometry) did not.
- There was poor correlation between POEM and observer-reported measures; and poor correlation between all these measures and corneometry.
- The characteristics of POEM and EASI supports their recommendation by HOME as core outcomes in trials of eczema treatments.

Abstract

Background: Eczema affects ~20% of children but multiple different outcome measures have hampered research into the effectiveness of different treatments.

Objectives: To compare the change in scores and correlations within and between five measures of eczema severity: Patient Orientated Eczema Measure (POEM), Eczema Area Severity Index (EASI), Six Area Six Sign Atopic Dermatitis (SASSAD), Three Item Severity (TIS), and skin hydration (corneometry).

Methods: Data from a feasibility trial that randomised young children with eczema to one of four emollients were used. Participants were followed for three months (84 days). Descriptive statistics (by emollient over time) and Spearman's correlation coefficients comparing scores at each time-point and absolute change (between adjacent time-points) for each outcome measure were calculated.

Results: 197 children, mean age (SD) of 21.7 (12.8) months, were randomised. POEM and TIS appeared to capture a range of eczema severity at baseline but only POEM had close approximation to normal distribution. Mean POEM, EASI, SASSAD and TIS scores improved month-by-month, with POEM showing the greatest sensitivity (effect size 0.42). Correlations within POEM, EASI, SASSAD and TIS were moderate-to-good, decreasing over time. Correlations between measures were strongest for EASI, SASSAD and TIS. By contrast, corneometry scores were more variable, correlated less well over time, and were poorly correlated with the other measures.

Conclusions: Except for corneometry, all measures appear to change in relation to emollient use over time and correlate well with themselves. POEM demonstrated the greatest range of scores at baseline and change in eczema severity over the first 28 days.

Introduction

Eczema, otherwise known as atopic eczema or dermatitis, is a common and troublesome condition, with the greatest burden of disease occurring in pre-school age children.[1] Despite this, evidence to support the use of fundamental treatments such as emollients and topical corticosteroids (TCS) is lacking.[2]

To be able to compare the effectiveness of different treatments, and inform clinical decision making, valid and reliable measures of the outcomes of interest are needed. However, different trials have employed a plethora of different measures, with more than 20 different

instruments to measure disease severity,[3] 14 to measure quality of life,[3] and 18 to capture patient symptoms.[4] Because these instruments assess different aspects of eczema in different ways, the results cannot be compared in meta-analyses. Consequently, evidence-based clinical decision-making has been hampered.

To address this, the Harmonising Outcome Measures for Eczema (HOME) group was established in 2010 to establish a core outcome set,[5] defined as an agreed standardised set of outcomes that should be measured and reported, as a minimum, in all clinical eczema trials.[6] So far it has recommended the Patient Orientated Eczema Measure (POEM)[7] and the Eczema Area Severity Index (EASI)[8] for the patient-reported symptoms and observer-reported measures of eczema severity, respectively. However, to date there has been limited research comparing the performance of these and other commonly used measures (e.g. Six Area, Six Sign Atopic Dermatitis Severity Score – SASSAD,[9] Three Item Severity score – TIS[10]) and how they quantify change in eczema severity over time (one measure of validity). In addition, it is common for manufacturers of emollients to evaluate their effectiveness in terms of changes in skin hydration, but how this relates to measures of eczema symptoms or signs is unclear.

We have used data from a feasibility trial comparing four commonly used emollients in children to compare change in scores over time and correlations within and between patient-reported (POEM), observer (EASI, SASSAD, TISS) and skin hydration (corneometry) measures of eczema severity.

Methods

Design, participants and interventions

Full details of the trial's methods have been published.[11] In brief, COMET was a feasibility study of a pragmatic, RCT to compare the clinical and cost-effectiveness of leave-on emollients in the treatment of childhood eczema.

Participants were recruited via general practice (GP) surgeries between July 2014 and April 2015. To be eligible, children had to have a clinical diagnosis of eczema, be aged one month to under five years and not known to be sensitive or allergic to any of the study emollients or their constituents.

Participants were randomly allocated by a web-based system (1:1:1:1 ratio) to one of four emollients (Aveeno® lotionl, Diprobase® cream, Doublebase® gel, or Hydromol® ointment) to use as their primary leave-on emollient with the directions to "Use twice daily and when required". All other care (appointments, prescriptions, referrals) was as per usual. Observers undertaking the baseline and follow-up visits (but not clinicians or parents) were masked to allocation.

Outcomes

Participants were followed for three months (84 days) by means of daily parent-completed diaries and observer visits (usually in the children's home) every 28 days. Day 1 was recorded as the date of the baseline visit.

Patient Orientated Eczema Measure (POEM) is a validated, seven item patient-reported outcome that asks about the frequency of seven symptoms (itch, sleep disturbance, dryness, flaking, weeping or oozing, bleeding and cracking) in the previous week.[7] It was collected at baseline and thereafter weekly by means of a parent-completed diary, and scores range from 0 to 28 (no to severe eczema). In addition, every 28 days, parents were asked to make a global assessment of how their child's eczema compared with one month ago (the Parent Global Assessment, PGA). Response categories (and scores) were: "Much better" (score of 2), "Better" (score of 1), "No difference" (score of 0), "Worse" (score of -1) or "Much worse" (score of -2).

Eczema Area Severity Index (EASI); Six Area, Six Sign Atopic Dermatitis (SASSAD), Three Item Severity (TIS) and corneometry (antecubital fossa and forearm, three measurements in each area) were collected by a masked observer at the baseline and follow-up visits. EASI, SASSAD and TIS are all scales for grading the physical signs of eczema. EASI scores (range 0 to 72) are calculated according to the presence of four features of eczema at four regions of the body.[12] SASSAD assesses the severity of six signs (erythema, exudation, excoriation, dryness, cracking and lichenification) in each of six areas (head and neck, trunk, hands, arms, legs and feet).[9] The TIS score is based on the evaluation of erythema, oedema/papulation and excoriation at a single representative site (range 0 to 9).[10]

Children with eczema are known to be born with a defective skin barrier associated with higher transepidermal water loss (TEWL). The application of emollients seeks replace moisture in the skin and/or reduce further water loss. Skin hydration was assessed using a corneometer (Corneometer® CM825, Courage & Khazaka electronic GmbH, Cologne, Germany), which is a simple and convenient device that measures skin electrical capacitance in the outermost layers of the epidermis. The corneometer was chosen over the measurement of TEWL primarily because of the portability and robustness of the instrument. While standardised procedures written in accordance with guidelines on biophysical skin measurements were followed,[13] measurements were taken in participant's homes under uncontrolled conditions. Skin hydration (reported in this paper in arbitrary units from 0 (wet) to 100 (dry), i.e. a lower score is a more positive outcome) was analysed in a multivariate linear regression model adjusted for variations in room temperature and humidity.[13]

Sample size

The main aim of the original trial was to determine the feasibility of a definitive trial to compare the clinical effectiveness of four different types of emollients, not the responsiveness, etc of the outcomes per se. Therefore a formal sample size calculation was not required. The target sample size of 160 randomised participants was pragmatic.[11]

Hypotheses about changes in scores and strengths of correlations

We hypothesised that the three different types of measure (parent-reported, observer-reported and corneometry) would all show improvement in eczema severity/hydration in relation to emollient use over time (from baseline to 3 months) and in relation to the PGA. We also expected to see: a stronger correlation between PGA and POEM, than that between PGA and the other measures; stronger correlations between observer-measures (EASI, SASSAD and TIS) than between patient-reported (POEM), observer-reported, and skin hydration measures; and for those correlations to all be in the same direction (less severe eczema/better skin hydration).

Analysis

Simple descriptive statistics (mean and standard deviation (SD), median and interquartile range, (IQR), minimum and maximum values) were calculated for all outcome measures, together with the proportion of participants with minimum and maximum scores at baseline and the first follow-up month.

Change scores were calculated by subtracting the current month's score from that of the previous month. Therefore, a positive change is an improvement over time. As the POEM was assessed weekly, the first month's score was equated to that of the last week, i.e. month 1 = week 4, and so on. Responsiveness is the ability of an outcome measure to detect change over time,[14] which is reported as an effect size (mean change in score at day 28/baseline SD).

Spearman's correlation coefficients were calculated, comparing raw scores of each outcome measure over time and absolute change scores (between adjacent time points) in each outcome.[15] Bootstrap 95% confidence intervals (CI) were calculated for the Spearman's correlation coefficients of absolute change scores as there were multiple observations of each outcome per participant due to multiple time-points where outcome measures were collected. Regarding interpretation of the strength of correlations, we adopted the accepted "rules of thumb" of >=0.70 as strong, 0.50-0.69 as moderate and <=0.50 as weak.[16]

Ethics

COMET was approved by the Central Bristol Research Ethics Committee (REC reference: 13/SW/0297); Clinical Trial Authorisation was granted by the Medicines and Healthcare products Regulatory Agency (MHRA reference: 03299/0017/001-003), and research governance approvals were obtained across all areas prior to the start of recruitment. The trial was prospectively registered with ISRCTN (21828118) and EudraCT (2013-003001-26). No additional ethical approval was required for the present study.

Results

Participant recruitment, characteristics and follow-up

Participant recruitment and follow-up by treatment allocation are shown in Figure 1. Participant's detailed characteristics are presented in Table S1. In summary, 197 children were randomised, with a mean age (SD) of 21.7 months (12.8), 85 (43%) female and 155 (85%) white. For various parent-related reasons, the follow-up appointment to acquire the observer-collected measures did not always take place when due (Figure S1). Overall, 75.7% of visits took place +/- 5 days and 97.3% took place +/- 10 days of scheduled follow-up dates.

Distributions of measures at baseline

Baseline eczema severity and corneometry are presented in Table 1, and Figure 2 shows the baseline score distributions. POEM displays a close approximation to a normal distribution, with scores across its whole range: 5 (2.6%) participants scored the minimum (0) and 1 (0.5%) scored the maximum (28). While some participants had minimum and maximum scores on TIS, none had the maximum scores on SASSAD and EASI, and all three measures were more negatively skewed.

Summary measures for corneometry at the two sites were similar at baseline and follow-up (Table 1), and were approximately normally distributed. Active eczema, which may affect the readings, was reported more commonly at the antecubital site at baseline (32.6%, 58/178 vs 19.2%, 34/177) and at the first follow-up visit (23.7%, 36/152 vs 11.8%, 18/152).

Mean measure scores and changes over time

Figure 3 shows the mean scores and 95% CIs for POEM, EASI, SASSAD, TIS and corneometry for each emollient over the three follow-up time points. As expected, scores decreased over time for POEM, EASI, SASSAD and TIS, reflecting an improvement in participants' eczema. In contrast, corneometry readings over time were much more variable, with apparent worsening (higher scores) for some emollients.

The greatest improvement in eczema severity (for all measures except corneometry) was observed over the first 4 weeks (Table S2). Score averages, ranges, and changes in scores over this period are summarised in Table 1. The largest effect size estimate over this time was observed with POEM.

Correlations within measures

When compared across the different time points, POEM, EASI, SASSAD, TIS all appear to have moderate-to-good (0.41 to 0.80) correlations with themselves (Table 2).[17] That is, the scores at baseline, visit one, and visit two correlated well with subsequent scores. The correlations become less strong the greater the time interval between measurements, i.e. correlations between baseline-visit one, visit one-visit two and visit two-visit three were all higher than baseline-visit two, baseline-visit three. Corneometry generally correlated less well over time.

Correlations between measures

Correlations of change scores over time between measures, and in relation to PGA, at all time points are presented in Table 3. As hypothesised, the strongest correlations were seen between the observer-reported measures: EASI and SASSAD (0.70, 95% CI 0.65 to 0.76), SASSAD and TIS (0.59, 95% CI 0.52 to 0.66) and EASI and TIS (0.51, 95% CI 0.43 to 0.59). In decreasing order of strength of correlation, POEM, SASSAD, EASI and TIS were correlated with PGA. The weaker correlations between POEM and EASI, SASSAD and TIS, and the moderate correlation between POEM and PGA, were also expected. Corneometry was very poorly correlated with all other measures.

Discussion

Summary

We believe that this is the first paper of its type to compare patient, observer and corneometry measures of eczema severity/skin hydration using a sizeable dataset collected from a community-based population. At baseline, the POEM and TIS measures captured a range of eczema severity (participants with minimum and maximum scores) but only POEM was shown to have a close approximation to the normal distribution. Mean POEM, EASI, SASSAD and TISS improved month-by-month, with POEM showing the greatest sensitivity to change (effect size 0.42). Correlations within POEM, EASI, SASSAD and TIS were moderate-to-good, decreasing over time. Perhaps unsurprisingly, the observer-administered measures (EASI, SASSAD and TIS) correlated mostly strongly. On the other hand, corneometry scores were more variable, correlated less well over time, and were poorly correlated with the other measures.

Strengths and weaknesses

Unlike previous comparable studies (see below), data were obtained from children recruited from the community who were taking part in a pragmatic trial. The parameters describing the performance of the different measures are therefore representative of most children with eczema, who have mild or moderate disease. In addition, comparing measure responsiveness over the period of greatest change (between baseline and visit one) gave a more conservative estimate of each measure's performance. The same observer undertook the EASI, SASSAD and TIS assessments together at each visit, but monthly follow up of each participant was not necessarily conducted by the same observer. This may have increased measure variability between visits, but the within measure comparisons between visits (Table 2) and between measures across visits (Table 3) should not be artificially inflated. We did not did not undertake any inter-rater reliability work so we are unable to comment in this.

Different methods are available to measure the water content of the outer layers of epidermis and there are few studies comparing these approaches with the patient-reported or clinical assessments in our study. Corneometry readings were collected in participants' homes with variable temperature and humidity, which we measured and adjusted for in our analyses.[13] However, the observed variability in readings may reflect other factors, such as time since bathing or application of emollient. While it is possible that corneometry measurements may reflect differences in the properties of different emollients, the original trial (and therefore this study) was not designed to compare outcome measures between the treatment groups over time. The apparent worsening in skin hydration may be the result of parents remembering to avoid emollient application close to the time of the observer visit and corneometry measurement.

Most participants in COMET were white and the measures may perform differently in children with darker skin. The numbers analysed at each subsequent time point decrease either because of missing data or due to participant withdrawal from the study. Because POEM was collected using a parent-completed diary, while the other measures were acquired at the "monthly" follow-up visits, the parent and observer-reported measures were not done on the same day. However, over three-quarters of visits took place within 5 days, and 97% within 10 days, of the scheduled dates. Finally, there was only a patient global assessment against which to compare these measures, not an investigator global assessment (IGA). Therefore, while in a separate paper,[18] we have estimated the minimal clinically important difference (MCID) for POEM, we have been unable to undertake comparable analysis for EASI, SASSAD or TIS. Typically, 0.5 of baseline SD is used to estimate MCID, yielding: EASI 1.9, SASSAD 4.2 and TIS 0.9.

Literature

The measurement properties of the POEM, EASI, SASSAD and TIS have recently been reviewed by Schmitt et al[19] and Gerbens et al.[4] POEM has mainly been evaluated in secondary or tertiary care populations and the methodological quality of the studies have mostly been judged to be fair or poor.[4] The evidence is strongest for its internal validity, content validity, responsiveness and interpretability. Our findings provide new evidence for its responsiveness to change,[4] in children with mainly mild/moderate eczema. Other studies will help address concerns about the absence of redness and pain/soreness as symptoms, the focus of POEM on frequency rather intensity of symptoms, and its lack of structural and cross-cultural validation.[4]

As for the objective measures examined in this paper, few studies have been undertaken in primary care settings (EASI 1/9, SASSAD 1/5, TIS 3/7).[19] Evidence of content validity, internal consistency, intra-observer reliability and sensitivity to change is greatest for EASI, while evidence of floor/ceiling effects is better for SASSAD and TIS.[19] We present novel data on floor/ceiling effects for EASI, and sensitivity to change for SASSAD and TIS. Schmitt et al[19] have previously noted that the content and measurement properties of patient-reported (SA-EASI and PO-SCORAD) and objective measures (EASI and SCORAD respectively) differ substantially. The lower correlation we report between POEM and EASI, SASSAD and TIS provides further evidence that they should not be used interchangeably.

Many different patient and clinician-reported measures have been variously compared in other studies, but few published papers have compared between the eczema severity measures presented here. EASI was found to be correlated with SASSAD (r = 0.86) in one study of 50 Korean children,[20] while SASSAD, EASI and TIS[21] and POEM and EASI[22] and have recently been compared in two small studies (12 and 25 participants, respectively) of patients (9 and 13 children, respectively) with moderate or worse eczema. Good inter-rater reliability was reported for EASI and SASSAD but not for TIS; however, excellent intra-rater reliability for EASI and TIS and good intra-rater reliability for SASSAD was found. No correlation was seen between POEM and SASSAD, EASI or TIS; no other between-measure correlations were reported.

While we found poor correlation between skin hydration measured using corneometry and all other measures, Holm et al[23] have reported a moderate correlation (r = -0.53) between EASI and skin capacitance. Correlations have also been reported with other objective measures of eczema severity (SCORAD[23-25] ADSI[23]). However, studies were smaller, the ages and severity of participants in these differ to the present one and some measurements were taken from different sites after acclimatising in a room with fixed temperature and humidity. Even in controlled settings, corneometry is less precise compared to other methods[26] and, as discussed above, other factors may have contributed to the variability that we observed.

Research and practice

The findings of our study support the adoption by HOME of POEM and EASI as the core patient and observer (including clinician)-reported outcome instruments, respectively, for trials of eczema treatments. We have provided further evidence that patient-reported and objective measures of eczema severity are not inter-changeable. Therefore, whether being used in the clinic, or as part of a research study, the choice of measure should reflect which perspective is judged to be of greatest importance (or possibly both types of assessment should be used). Correlations within these groups (POEM with PGA; EASI, SASSAD and TIS with each other) are reasonable though, meaning other properties of the measures need to be considered when deciding which one to use. Our findings of high variability in the corneometry readings over time, and the low correlations with other measures, question whether this method should be used to determine the effectiveness of emollients or other topical treatments for eczema, at least in community/pragmatic trial settings.

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Table 1: Total scores and change of scores on individual measures

Measure	Scale range	Baseline (day 1)								Visit 1 (day 28)								Change score	
		Mean (SD)	Median (25^{th}, 75^{th} percentile)	Range						Mean (SD)	Median (25^{th}, 75^{th} percentile)	Range						Mean (SD)	% effect size†
				Min			Max					Min			Max				
				Score	%	n	Score	%	n			Score	%	n	Score	%	n		
POEM	0 – 28	8.8 (5.9)	8 (4, 12)	0	2.6	5	28	0.5	1	5.7 (5.4)	4 (2, 8)	0	11.1	17	27	0.7	1	2.5 (4.9)	42.4
EASI	0 – 72	2.9 (3.8)	1.6 (0.6, 3.8)	0	6.5	12	26	0.5	1	2.3 (3.1)	1 (0.4, 3.2)	0	10.9	17	23.2	0.6	1	0.5 (2.2)	13.2
SASSAD	0 – 108	8.8 (8.4)	6 (3, 11)	0	3.8	7	46	0.5	1	7.5 (7.4)	5 (3, 10)	0	5.0	8	37	1.3	2	0.91 (4.7)	10.8
TIS	0 – 9	2.0 (1.7)	2 (1, 3)	0	12.4	23	9	0.5	1	1.9 (1.7)	1 (1, 2)	0	17.0	27	8	0.6	1	0.1 (1.5)	5.9
Corneometry																			
Forearm	0 – 100	68.0 (11.2)	68.4 (60.3, 76.1)	33.6	0.6	1	99.5	0.6	1	64.8 (12.6)	67.2 (60.4, 71.5)	19.6	0.7	1	89.7	0.7	1	3.1 (11.3)	27.7
Antecubital fossa	0 – 100	62.2 (13.9)	63 (54.3, 72.7)	13.4	0.6	1	94.6	0.6	1	61.1 (13.0)	60.7 (54.7, 68.8)	26.7	0.7	1	96.6	0.7	1	1.4 (14.5)	10.1

† Mean change score/baseline SD

Table 2: Comparison within measures: POEM, EASI, SASSAD, TIS and corneometry
Spearman's correlation coefficient between outcome measurements at four different time-points

	Baseline	Visit 1	Visit 2	Visit 3
POEM				
Baseline	1			
Month 1	0.4967	1		
Month 2	0.4121	0.6831	1	
Month 3	0.4062	0.5739	0.7080	1
EASI				
Baseline	1			
Month 1	0.6629	1		
Month 2	0.5456	0.6034	1	
Month 3	0.4986	0.4981	0.5862	1
SASSAD				
Baseline	1			
Month 1	0.7071	1		
Month 2	0.5945	0.6515	1	
Month 3	0.5391	0.5853	0.6447	1
TIS				
Baseline	1			
Month 1	0.5692	1		
Month 2	0.4142	0.4799	1	
Month 3	0.3924	0.4230	0.6167	1
Corneometry antecubital fossa				
Baseline	1			
Month 1	0.2699	1		
Month 2	0.1996	0.3732	1	
Month 3	0.3573	0.4485	0.3224	1
Corneometry forearm				
Baseline	1			
Month 1	0.5287	1		
Month 2	0.4633	0.6140	1	
Month 3	0.2579	0.3934	0.5151	1

Table 3: Comparison of change between POEM, EASI, SASSAD, TIS and corneometry (antecubital and forearm) over all time points

	POEM	EASI	SASSAD	TIS	Corneometry antecubital fossa	Corneometry forearm	PGA
POEM	1						
EASI	0.20 (0.09, 0.30) 0.000	1					
SASSAD	0.26 (0.17, 0.36) 0.000	0.70 (0.65, 0.76) 0.000	1				
TIS	0.12 (0.02, 0.22) 0.020	0.51 (0.43, 0.59) 0.000	0.59 (0.52, 0.66) 0.000	1			
Corneometry antecubital fossa	0.02 (-0.09, 0.13) 0.714	0.16 (0.05, 0.27) 0.003	0.13 (0.02, 0.23) 0.017	-0.03 (-0.14, 0.08) 0.589	1		
Corneometry forearm	0.09 (-0.02, 0.20) 0.112	0.09 (-0.02, 0.20) 0.091	0.11 (0.00, 0.23) 0.044	0.10 (-0.01, 0.20) 0.070	0.35 (0.25, 0.45) 0.000	1	
PGA	0.40 (0.31, 0.49) 0.000	0.33 (0.24, 0.41) 0.000	0.37 (0.29, 0.46) 0.000	0.24 (0.15, 0.33) 0.000	0.04 (-0.07, 0.15) 0.487	0.03 (-0.08, 0.14) 0.614	1

Spearman's correlation coefficient comparing absolute change (between adjacent time points) in each outcome with bootstrapped 95% confidence intervals and p-values.

Corneometry outcomes are the results from the defined model (reported here as lower score representing a positive outcome of more hydrated (wet) skin)

Figure 1: CONSORT – recruitment and follow-up by treatment allocation

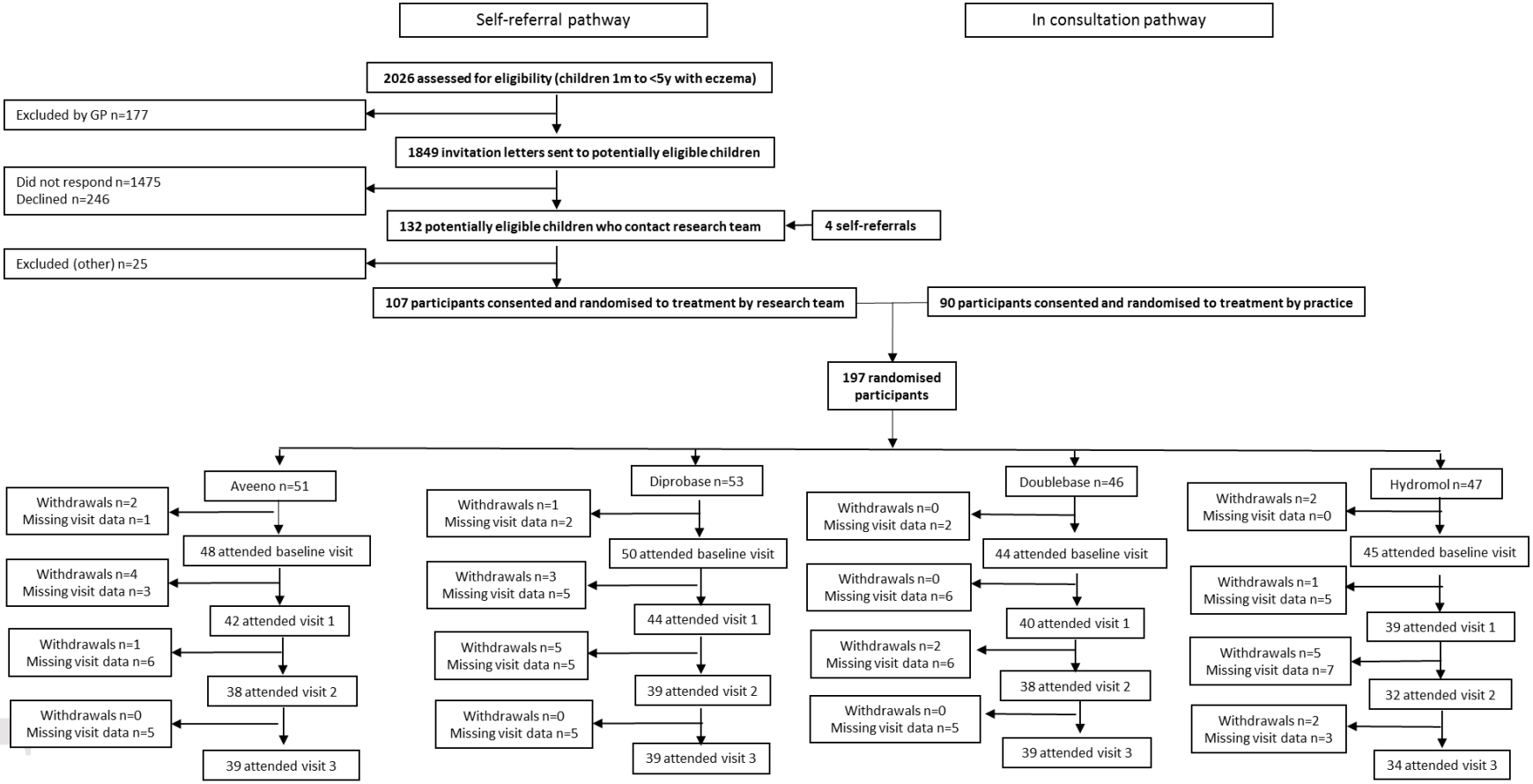

Figure 2: Distribution of POEM, EASI, SASSAD, TIS and corneometry at baseline

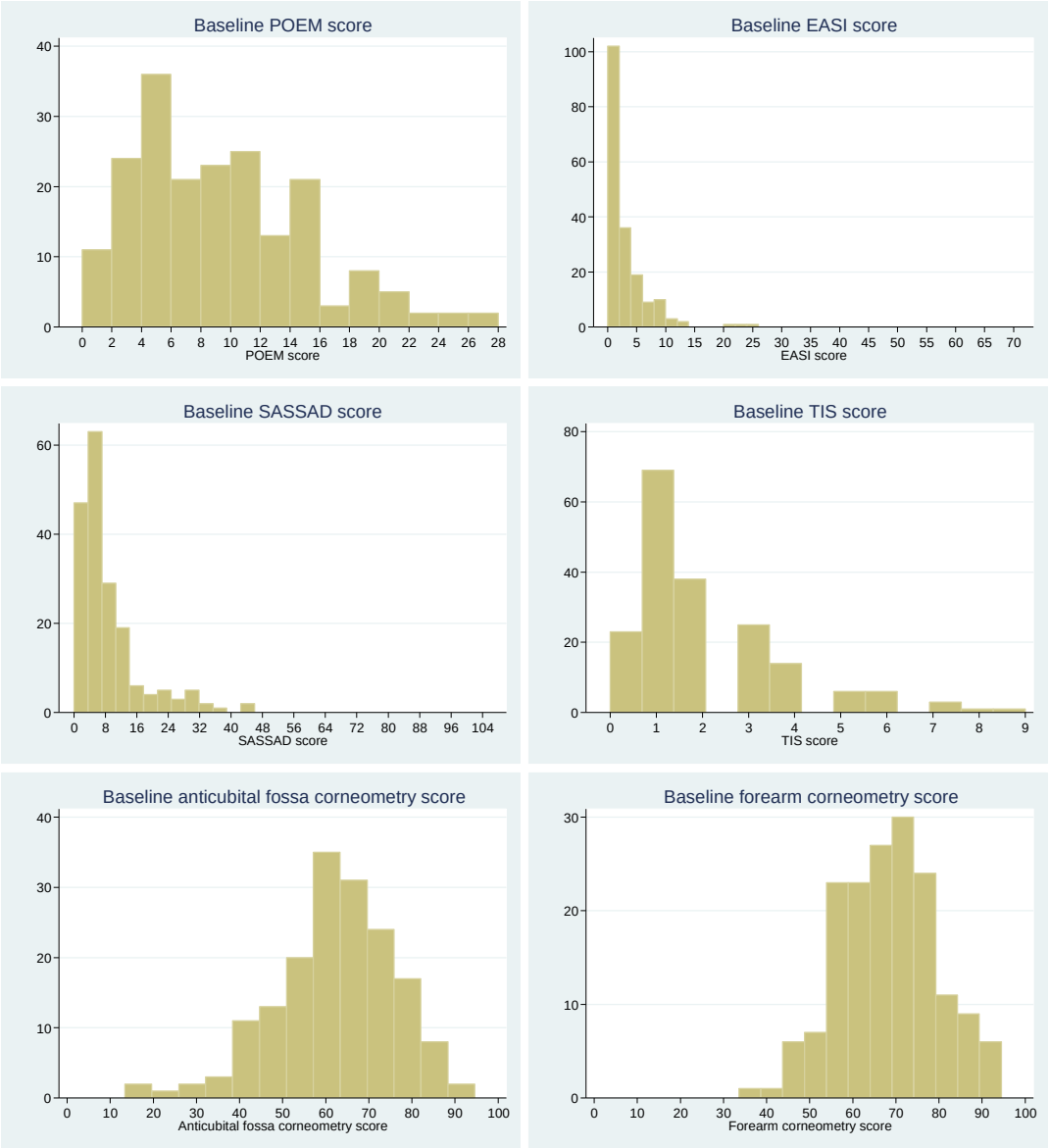

Figure 3: Mean POEM, EASI. SASSAD, TIS and corneometry (95% CI) over time by emollient